



Ontology-driven Geospatial Process Modeling based on Web-service Chaining

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Agenda

- **Introduction**
- **Geospatial Process Model**
- **Ontology-based Knowledge Base**
- **OGC Catalog Service for Web (CSW)**
- **Life cycle of Geospatial Process Modeling**
- **Conclusion**



Introduction

- **GeoBrain** (<http://geobrain.laits.gmu.edu>)
 - A Web Service based geospatial knowledge system
 - *Produce the user specific data products by creating and executing geospatial process models (service chain/workflow)*

NASA EOS Higher-Education Alliance (NEHEA) -- GeoBrain
Mobilization of NASA EOS Data and Information through Web Services and Knowledge Management Technologies for Higher-Education Teaching and Research

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WHAT'S NEW

June 2006: **NEW** [GeoBrain Data Download 2.0](#) is released with new features.

May 2006: **NEW** [2006 GeoBrain Partner RFP](#) is released

April 2006: **NEW** [GeoBrain Data Download 1.1](#) is released for helping users to download data. [New features...](#)

February 2006: [GeoBrain issues/bugs tracking system](#) is released for helping users to report system errors. [See instruction.](#)

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Introduction

- **Virtual Data Product**
 - Much geospatial scientific data is not obtained directly from measurements but rather derived from other data by the application of **computational procedures**.
 - *Landslide susceptibility (slope, aspect, NDVI...)*
- **Geospatial Process Model**
 - Abstract computational procedure
 - Behavior-based high level geospatial knowledge.



Introduction

- **Web Service**
 - “A Web service is a software system designed to support interoperable machine-to-machine interaction over a network.” (<http://www.w3.org/TR/ws-arch/>)
- **Web Service Orchestration**
 - Assembling individual Web Services into a service chain (representing a more complicated geospatial model and process flow) to achieve desired results

By wrapping data and process with Web services, it is easy to transform a geospatial process model into a service chain and execute it regardless of their heterogeneity.



Geospatial Process Model

- **Geospatial Process** – *transform geospatial data from one state to another state.*
 - Atomic Process: *runs independently*
 - Composite Process: *a sequence of processes in a predefined pattern.*

```
<process:AtomicProcess rdf:ID="isodata_cls_process">
  <!-- conditional inputs -- >
  <process:hasInput rdf:resource="#clusters"/>
  <process:hasInput rdf:resource="#iteration_number"/>
  <process:hasInput rdf:resource="#target_data_format"/>
  <!-- data inputs -- >
  <process:hasInput rdf:resource="#source_data_url"/>
  <process:hasInput rdf:resource="#source_data_format"/>
  <!-- outputs -- >
  <process:hasOutput rdf:resource="#target_data_url"/>
</process:AtomicProcess>
```



Geospatial Process Model

- Geospatial Process Model

A tree-like composite process generated by chaining other processes in which the components and control structures contain the knowledge of a specific application domain.

```

<process:composedOf>
<process:Sequence>
<process:Chain>
<process:Perform>
<process:Split>
<process:Perform
rdf:ID="proc_1">
<process:process
rdf:resource="#slope_proc"/>
</process:Perform>
<process:Perform Perform
rdf:ID="proc_2">
<process:process
rdf:resource="#aspect_proc"/>
</process:Perform>
</process:Split>
</process:Perform>
</process:hasDataFrom>
<process:Binding>
<process:theParam
rdf:resource="#slope_data"/>
</process:Binding>
<process:valueSource>
<process:ValueOf>
<process:theParam rdf:resource="#O11"/>
<process:fromProcess
rdf:resource="#proc_1"/>
</process:ValueOf>
</process:valueSource>
</process:Binding>
</process:hasDataFrom>
<process:hasDataFrom>
<process:Binding>
<process:theParam
rdf:resource="#aspect_data"/>
</process:Binding>
<process:valueSource>

```

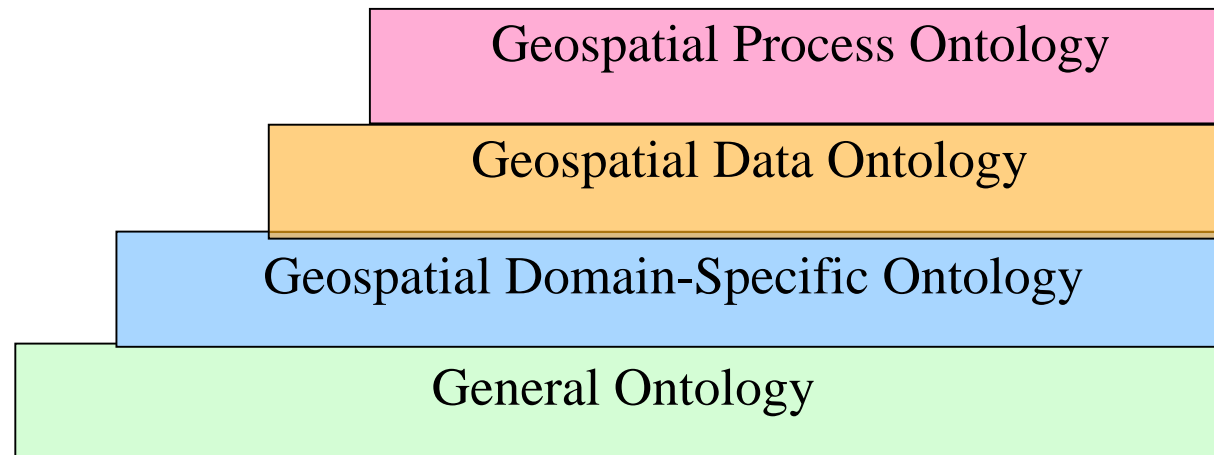


Ontology-based Knowledge Base

- **Ontology** – *specification of conceptualization*
 - Capture geospatial domain knowledge, *i.e. domain terms and concepts, linkage between processes and data, relationships among heterogeneous data.*
 - Help users to efficiently find the best solutions and the most appropriate data.



Ontology-based Knowledge Base



Geospatial Ontology is a knowledge representation tool for modeling the concepts of the geospatial domain, including representation of geospatial processes, data, and spatial relationships. It is a knowledge representation tool for modeling the concepts of the geospatial domain, including representation of geospatial processes, data, and spatial relationships. It is a knowledge representation tool for modeling the concepts of the geospatial domain, including representation of geospatial processes, data, and spatial relationships.

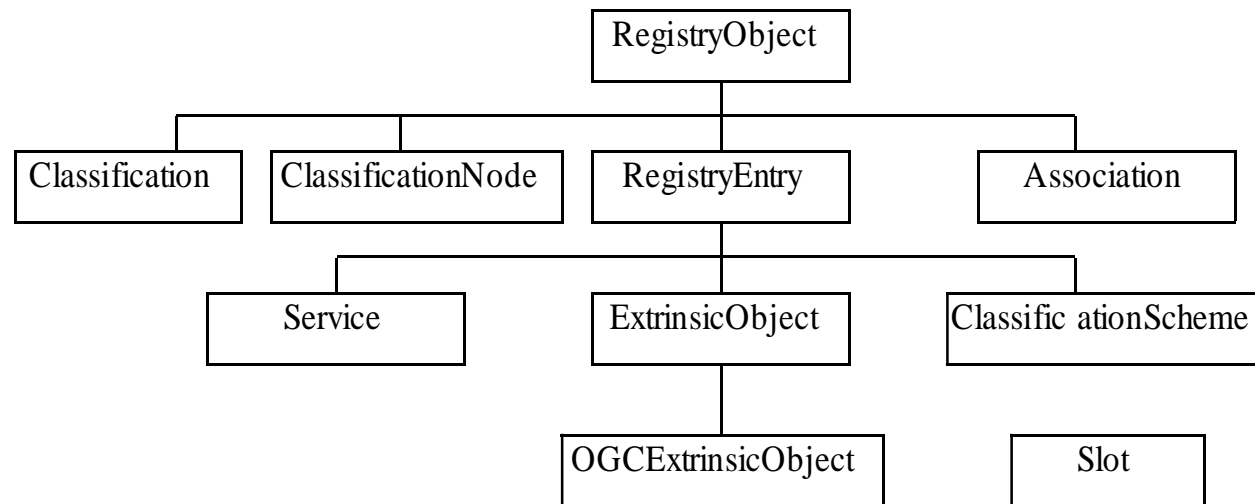


OGC Catalog Service for Web (CSW)

- **Directory Role**
 - Providers advertise the availability of their resources, and consumers can then query the metadata to discover and run-time access them.
- **EB/RIM Information Model**
 - Specifies formally how domain objects are organized, constrained and interpreted based on domain conceptual structure.
- **Standard Interfaces**
 - GetCapabilities, describeType, getRecord...
- <http://geobrain.laits.gmu.edu/csw/discovery/>



OGC Catalog Service for Web (CSW)



OGCRIM Class Hierarchy.



OGC Catalog Service for Web (CSW)

- **Semantic Matching**

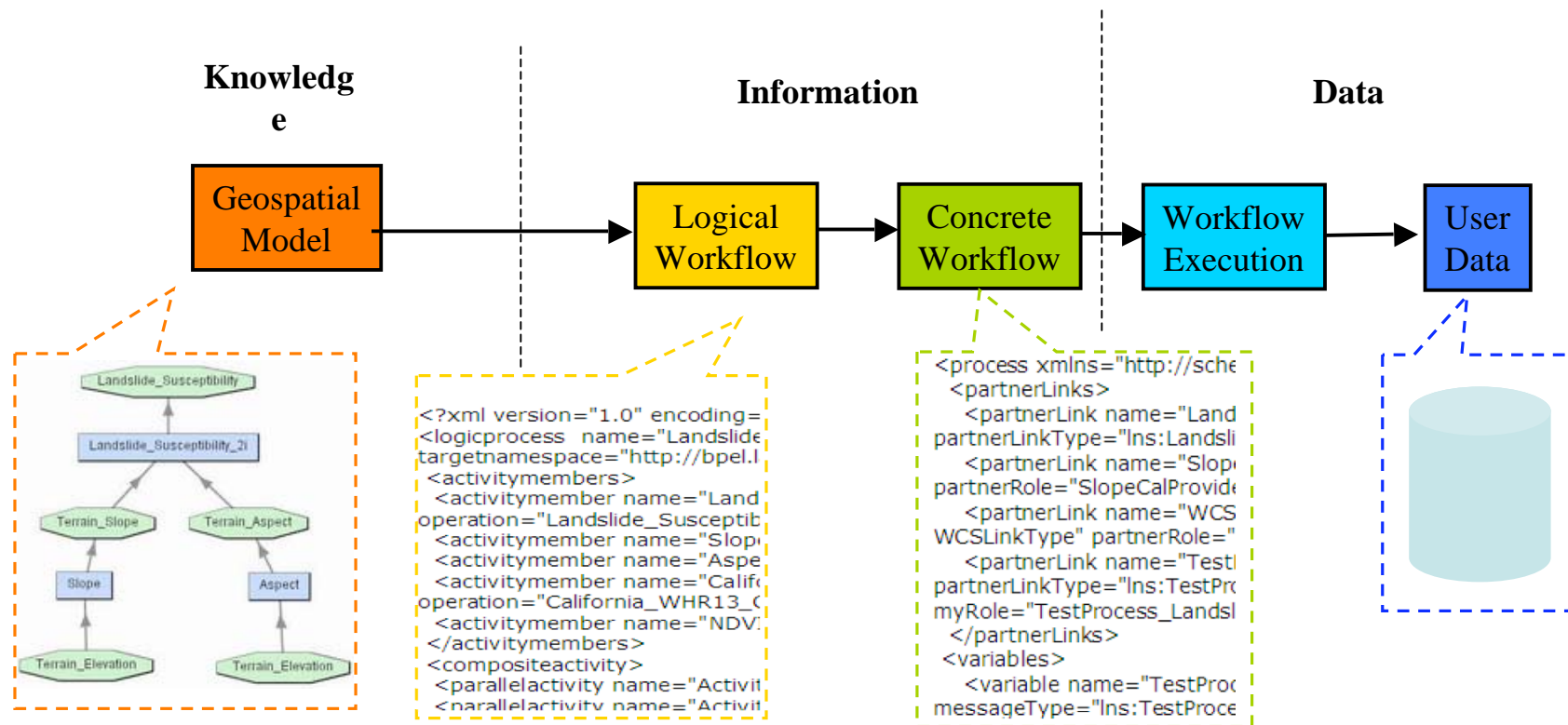
Go: the output of a geospatial service type

R: request

- 1) exact, if $Go = R$, then *Go* and *R* are exact equivalent;
- 2) plug in, if *Go* subsumes *R* than *Go* could be plugged in place of *R*;
- 3) subsume, if *R* subsumes *Go*, then *Go* just completes part of *R* and *R* needs other *Go* to implement the other part of *R* or whole *R*;
- 4) fail, there is no relationship between *Go* and *R*.



Life Cycle of Geospatial Process Modeling





Toolkit

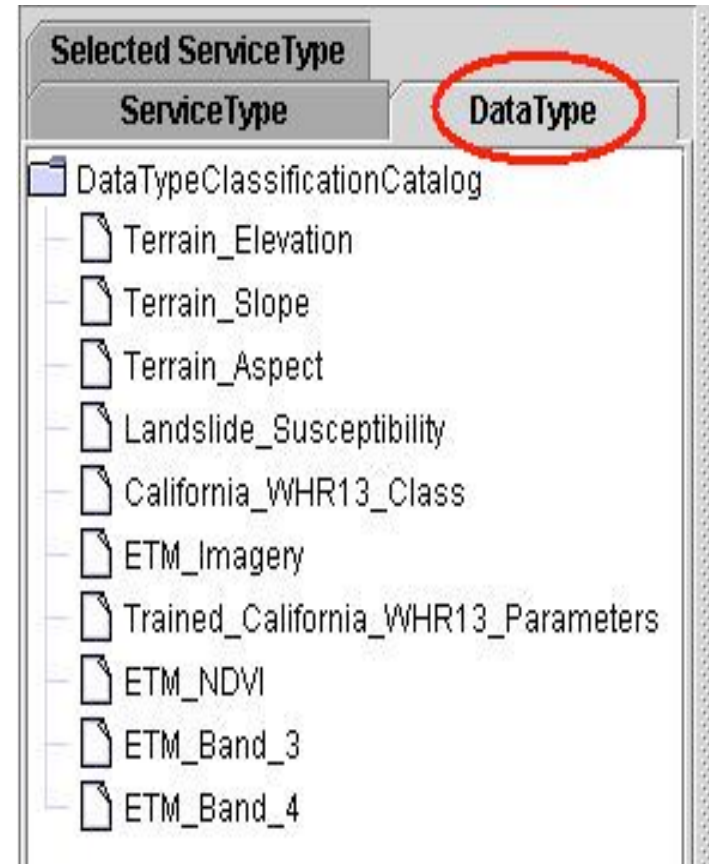
- **Toolkit**
 - With geospatial knowledge
 - *Design*
 - *Discovery*
 - *Retrieve*
 - *Chain*
 - *Orchestrate*
 - *Visualization*



Geospatial Model Designer

- **Data Type**

- Data type is a class of data having the same scientific meaning.
- The data type hierarchical list is chosen according to the scientific terminology of discipline domain.
- Each data registered in the catalogue is associated with some data types.

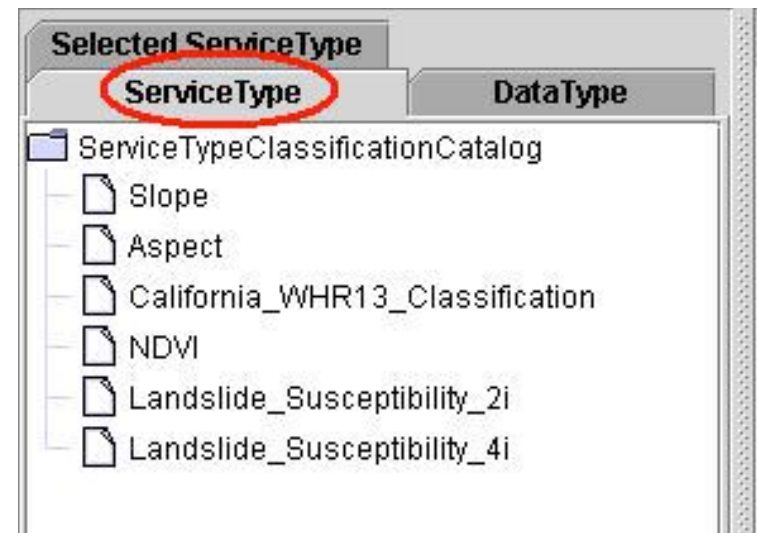
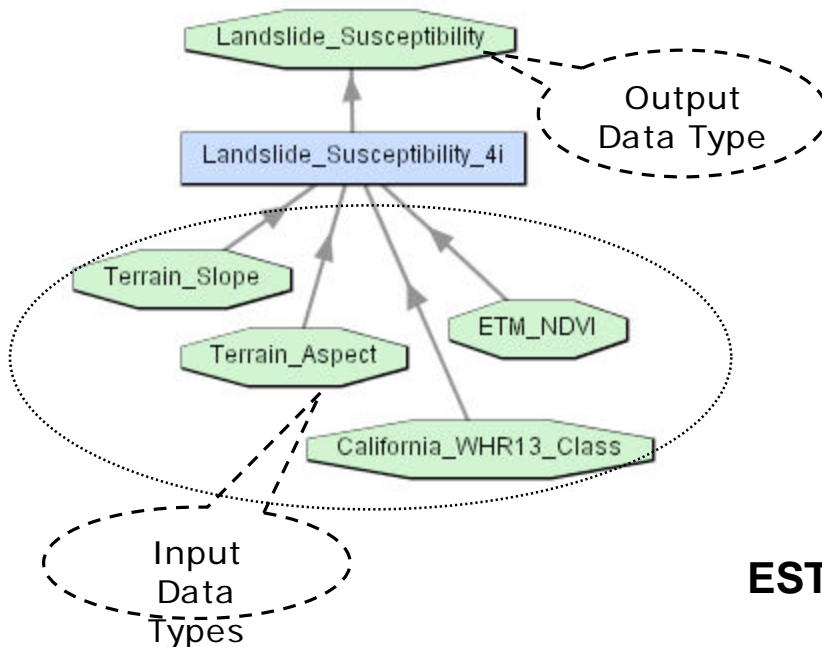




Geospatial Model Designer

- **Service Type**

- Service type is a class of services having the same input data types and output data type.
- Each service registered in the catalogue is associated with a service type.

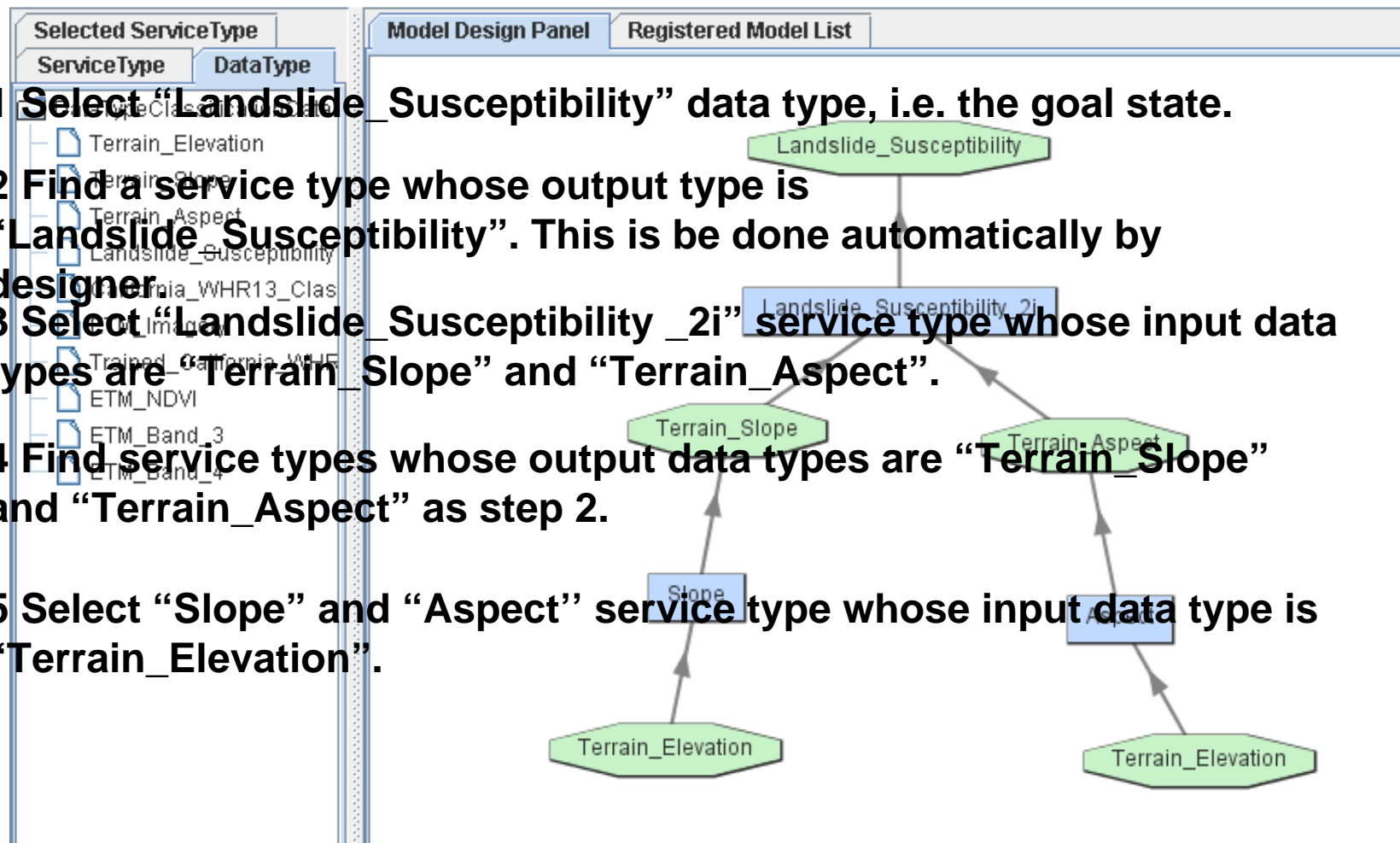




Geospatial Model Designer

- <http://laits.gmu.edu/vdp/>

- 1 Select “Landslide_Susceptibility” data type, i.e. the goal state.
- 2 Find a service type whose output type is “Landslide_Susceptibility”. This is be done automatically by designer
- 3 Select “Landslide_Susceptibility _2i” service type whose input data types are “Terrain_Slope” and “Terrain_Aspect”.
- 4 Find service types whose output data types are “Terrain_Slope” and “Terrain_Aspect” as step 2.
- 5 Select “Slope” and “Aspect” service type whose input data type is “Terrain_Elevation”.





Virtual Data Service

- **Instantiation**

- Input: logical workflow
- Output: BPEL process
 - *BPEL4WS (Business Process Execution Language for Web Service)*
 - A language for the formal specification of business processes and business interaction protocols. By doing so, it extends the Web Services interaction model and enables it to support business transactions.
- Service discovery
 - *Find a service instance for each service type in logical workflow*
- Data service add-in
 - *Find the most appropriate existing data (at the bottom of geospatial model) and add the relevant data services automatically, such as Web Coverage Service, Web Coordinate Transformation Service*



Virtual Data Service

- **Standard interfaces**

- OGC Web Coverage Service

- *getCoverage*

<http://laits.gmu.edu:8099/AWCSPortal/AWCSPortal?service=AWCSPortal&request=getCoverage&version=1.0.0&coverage=VIRTUAL:landslide2i&crs=EPSG:4326&bbox=-122.2656,37.5993,-122.0013,37.8778&format=HDF-EOS&width=100&height=100&resx=1000&resy=1000&axisname=NewAxis&axisvalue=Decarl&submit=submit>



BPELPower – Service Chain Engine

- **Based on the mainstream standards**
 - BPEL, WSDL, WSIF, Xalan, Xerces, UDDI, AXIS, SOAP, JNDI, J2EE (servlets/EJBs/JSPs), Jetspeed (Portlets) and JMX. It runs on top of popular application servers, such as Tomcat, J2EE, JBoss, Weblogic and WebSphere.
- **“Deploy it”.**
 - WSDL-based web services and BEPLE-based web services chain can be deployed in BPELPower, where their validations are checked.
- **“Try it”.**
 - WSDL-based web services and BEPLE-based web services chain can be executed in BPELPower dynamically. Different invocations (e.g., HTTP POST/GET, SOAP document/rpc, etc.) are well supported.
- **See detail at <http://geobrain.laits.gmu.edu:8098/bpel>.**



BPELPower – Service Chain Engine

BPEL Process Manager - BPELPower - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://geobrain.laits.gmu.edu:8098/bpel

Web Model Designer Web Services Orchestration: ... BPEL Process Manager - B...

BPELPower BPEL Process Manager

WSDL Services BPEL Processes Instances LBPL Activities

Deployed WSDL Services

| Service Name | Service Name |
|--|--|
| CurrencyExchangeService | EMBLNucleotideSequenceWebService |
| GMU-NGA-WCS | GMU-WICS |
| Grass General CommandsService | Grass Imagery CommandsService |
| Grass Raster3D CommandsService | Grass Raster CommandsService |
| Grass Raster InOut CommandsService | Grass Vector CommandsService |
| Grass Vector InOut CommandsService | GridSlopeAspectService |
| GridSlopeService | GridWCSService Laits |
| GridWCSService No | GridWCSService |

[Deploy New Services](#) [Undeploy Services](#)

Logged to domain: **default** BPELPower v2.0.



Conclusion

- **Life cycle of geospatial process model**
 - Design (knowledge) → instantiation (information)
→ execution (data)
- **Interoperability**
 - Web Services
 - *Catalog service, Virtual data service, BPELPower...*
- **Expansibility**
 - Web Service chain
 - *Easily add new services to represent more complex product.*